ABSTRACT: The impact of innovation activities on the performance and competitiveness of firms, industries, and nations has been a matter of considerable interest over the past few decades. The existing empirical work has widened our knowledge of the complexity of the innovation process and its impact on the ability of firms to compete. This study investigates how knowledge spillovers generated through firms’ innovation activities affect the ability of their industries to compete in terms of quality. The data from the Community Innovation Survey 2006 for several EU member and candidate countries that have recently become available are combined with other EU-wide datasets to create an industry database containing information on innovation activities and performance at industry level. A simultaneous equations framework is used to examine the interdependencies between knowledge spillovers, innovation activities, quality upgrading, and the market share of industries from the selected countries in the single European market. The results of the investigation provide support for the relationship between innovation, quality upgrading, and market share of industries, and point to several types of spillover which are relevant for the competitiveness of national industries in EU member states.

KEY WORDS: Knowledge spillovers, Innovation, Competitiveness, EU market share

JEL CLASSIFICATION: O31, O33
1. INTRODUCTION

Few economic topics have been investigated with such enormous intensity over recent years as the impact of innovation activities on the performance and competitiveness of firms, industries, and nations. With the emergence of endogenous growth models and revived interest in Schumpeterian literature, knowledge and technology have been promoted into key engines of economic growth. The predictions of these models, that specialisation in knowledge-intensive goods improves the ability of nations to grow and to provide their citizens with a better standard of living, have shifted the emphasis of the international trade literature from the ability of nations to export towards the structure of their exported products. To this end, the development of policies which lead to improvements in quality-driven competitiveness has become one of the most important challenges facing all policymakers concerned with the prospects of their nations in a globalised world.

The empirical work in this field has developed in two directions. First, microeconomic studies have investigated the relationship between firms’ innovation activities and their performance and competitiveness. Using multi-stage models, this line of work has widened our knowledge of the complexity of innovation processes at the firm level and helped us to understand the diversity of incentives that motivate firms to innovate, the obstacles they face in making innovation expenditure and transforming innovation inputs into outputs, as well as the relationship between innovation outputs and the performance and competitiveness of firms (Crepon et al., 1996; Loof et al., 2001; Loof et al., 2006; Hashi and Stojcic, 2013). Secondly, macroeconomic studies have investigated the linkages between the structure of exported products and economic growth (Hummels and Klenow, 2005; Hausmann et al., 2007; Guerson et al., 2007). The findings from this body of knowledge suggest that the relative quality of exports has an important role in explaining why some nations grow faster than others.

Curiously enough, empirical studies have not taken much interest in the mechanisms of innovation at the industry level. In the presence of market imperfections, horizontal and vertical knowledge and technology spillovers generated through formal and informal enterprise networks, imitation of rivals’ actions, and cooperation with universities, research laboratories, and other scientific institutions can help firms to overcome barriers to innovation and raise the quality-driven competitiveness of the entire industry. Thus, innovation-driven spillovers may have an important role in explaining the market share of
industries from individual countries in the international market (Romer, 1990; Grossman and Helpman, 1991; Laursen and Meliciani, 2002; Javorcik, 2004).

This paper seeks to explore the influence of innovation activities on the ability of industries from a selection of EU member states and candidate countries to compete in terms of quality in the single European market. The novelty of this approach lies in the use of a simultaneous equations framework which enables us to examine the relationship between knowledge spillovers, innovation activities, quality upgrading, and industries’ EU market share while controlling for feedback effects at different stages of this process, and also the use of an industry-level database containing innovation activities and other characteristics of industries in selected countries. The paper is organised into six sections. Section 2 will establish the theoretical framework of the research and will be followed by a critical assessment of the related empirical work in Section 3. The model used in the investigation and the research methodology will be developed in Section 4 and the characteristics of the dataset and the descriptive statistics discussed in Section 5. The main findings of the econometric work will be discussed in Section 6. Section 7 will conclude.

2. THEORETICAL FRAMEWORK

In models of endogenous growth the ability of nations to grow and to provide their citizens with a better standard of living depends on their production of new knowledge or innovation (Romer 1986; 1990). In Schumpeterian fashion these models postulate that the opportunity to differentiate themselves from their rivals and to enjoy a temporary monopoly power acts as a continuous incentive for profit-seeking individuals to search for new and better ways of doing things (Aghion and Howitt, 1992; Grossman and Helpman, 1994; Aghion and Howitt, 1998). Through successive waves of innovation firms can improve the relative sophistication of their products and climb up the quality ladder. However, over time part of this knowledge becomes diffused through imitation, competition, or inter-firm networks improving the quality-driven competitiveness of the entire industry and consequently the economy.

Building on these foundations, the emphasis of international trade literature has moved from the ability of nations to export to the structure of their exported products (Hausmann et al., 2007). Given that an innovation bestows a temporary monopoly on a firm, specialising in high technology-intensive products enables nations to achieve higher rates of growth over longer periods of time (Grossman
and Helpman, 1991; 1994). Two important implications arise from such reasoning. First, the nations have an incentive to improve the relative sophistication of their exports in order to be able to compete in quality. Second, the efforts of nations to improve the quality of their exports, together with a demand for variety and economies of scale, can explain the rising phenomenon of intra-industry trade. The key issue for policy makers concerned with the ability of their countries to grow and provide their citizens with a better standard of living becomes the identification of mechanisms through which they can improve the ability of firms and industries to compete in quality.

In examining these issues endogenous growth models pay particular attention to the knowledge and technology spillovers which are identified as the key link between firms’ innovation activities and the quality-driven competitiveness of their industries. The spillovers are seen as a way for firms, particularly small ones and entrants, to overcome barriers to innovation such as the high costs of obtaining needed information and investment in human capital by relying on the efforts of their rivals, related firms, or supporting institutions. To this end private investment in innovation is seen as a path towards more general discoveries which are difficult to hide from rivals, and therefore get easily diffused across the industry. In addition, the stock of knowledge created through earlier cumulative investment may be used as a starting point by future innovators, allowing them to release additional funds and efforts in the development of new products and processes (Aghion and Howitt, 1992).

Early endogenous growth models treat knowledge and technology spillovers as side products of private innovation investment. The extension of their reasoning with the insights of new economic geography (Krugman, 1980; Venables, 1996; Hafner, 2008) sheds new light on the role of agglomeration externalities in explaining the ability of firms and industries to compete. The geographical proximity of firms to their rivals leads to within-industry economies, such as easier access to specialised input services and skilled labour. As noted by Grossman and Helpman (1994), a higher concentration of skilled workforce in geographically limited space facilitates the sharing of new ideas, contributing to the competitiveness of the entire industry. Similarly, cooperation with the research and science sector and mutual investment in basic knowledge and infrastructure may have an important role for small and medium-sized firms in overcoming barriers to innovation (Fallah and Ibrahim, 2004).

The knowledge and technology spillovers can be promoted through mechanisms of competition. The intensity of innovation-driven competition within industry
motivates non-innovating firms to allocate some of their efforts and funds to
the development of new products and processes in order to prevent innovative
rivals seizing their market share (Jaffe, 1986; Lelarge and Nefussi, 2008). Another
incentive in this direction comes from the pressure of imports (Monfort et al.,
2008; Ferndandes and Paunov, 2009). On one hand, inflow of price-competitive
non-innovative importers may act as an incentive for the movement of incumbent
firms towards the quality segment of the market in order to escape competition.
On the other hand, knowledge and technology spillovers arising from the
pressure of quality-competitive foreign rivals, in the form of either imports or
foreign direct investment in the domestic market, may prove to be a valuable
source of knowledge and technology spillover and motivate incumbent firms to
compete in quality (Grossman and Helpman, 1991; Baldwin et al., 2005). Similar
reasoning can be applied to firms participating in international markets, as the
ability to compete abroad leads to learning through the exporting mechanism
(Brooks, 2006).

Much of the interest in knowledge and technology spillovers is based on the
thesis that these processes can only exert a positive influence on the ability of
firms, industries, and nations to compete in quality. Yet, in the absence of a
technological hierarchy among firms, knowledge spillovers will result in a sub-
optimal rate of investment in research and development (Lhuillery, 2009). This
is caused by the fact that outgoing spillovers reduce the incentives of innovators
to search for discoveries, while high incoming spillovers provide other firms
with the opportunity to benefit from the efforts of their rivals. Similarly, under
asymmetric spillovers, technological followers will have the incentive to act as
free riders. Such behaviour will reduce the incentives of technological leaders
to innovate and erode the efficiency of the entire industry. The endogenous
growth theory considers that this deterring effect of innovation can be offset by
the activities of government: policies that facilitate the innovation activities of
firms may have an important role in explaining the ability of their industries to
compete.

Knowledge and technology spillovers can be of domestic or international origin.
The distinction between the two is particularly important for industries from
economies which have a lower position on the international quality ladder. If the
intensity of the innovation activities of domestic producers is low, the knowledge
and technology spillovers may be of little practical use for the quality-driven
competitiveness of industry when it finds itself in international markets. As a
consequence producers from these countries may find themselves locked in a
low-quality trap, competing in the international market with low technology-
intensive products with lower added value and leading to sub-optimal rates of growth (Dulleck et al., 2005). In contrast, the presence of international knowledge spillovers enables producers from laggard economies to access the knowledge accumulated by others and to catch up with them by mastering these discoveries. In this context, presence in foreign markets and technology transfer channels such as foreign direct investment or licensing of foreign technology may be of crucial importance.

To summarise, quality-driven competitiveness provides economic agents with the ability to generate higher added value and above-average rates of growth over a longer period of time. The ability of nations to compete in quality rests on their firms, while the link between the behaviour of firms and the competitiveness of their industries and economies lies in knowledge and technology spillovers. These spillovers can take place through various channels, from side products of investment in research to competition and agglomeration externalities, foreign direct investment, and licensing of technology. However, contrary to common belief, these spillovers can result in a sub-optimal level of investment in innovation if government policies that stimulate the innovation activities of firms are absent.

3. LITERATURE REVIEW

The seminal article by Crepon et al. (1998) resulted in an exhaustive body of work on innovation processes at the firm level (Loof et al., 2001; Kemp et al., 2003; Loof et al., 2006; Masso and Vahter, 2007; Hashi and Stojcic, 2013). Apart from pointing to the complexity of the innovation process and establishing the link between innovation activities of firms and their performance and competitiveness, this literature has highlighted the role of knowledge and technology spillovers as determinants of firm behaviour. One set of findings suggests that cooperation with universities, research laboratories, and other scientific institutions increases the probability of firms engaging in innovation and enhances their ability to transform innovation inputs into innovation outputs (Klomp and van den Leeuwen, 2001; Kemp et al., 2003). Furthermore, the formal and informal inter-firm spillovers realised through competition in the domestic (Loof et al., 2002) or foreign (Masso and Vahter, 2007) market play an important role in explaining the ability of firms to innovate. Finally, in economies which are technological followers, such as transition economies, the ability of firms to innovate seems to be higher if they belong to a group of enterprises or have foreign owners (Domadenik et al., 2008).
In parallel, the trade and growth literature has investigated the link between the relative sophistication of a nation’s exports and its economic growth. Schott (2008) points to the differentiation in the specialisation patterns of economies with different levels of GDP per capita. His findings indicate that economies with a low level of GDP per capita tend to specialise in low quality goods, while developed economies’ exports are associated with goods of higher quality. In the model of Hausmann et al. (2007) the quality of exports is defined in terms of the embodied productivity of exported goods. Their findings indicate that countries specialised in high productivity goods achieve higher rates of growth than those exporting goods with low productivity. Similar findings have been reported by Guerson et al. (2007). Yet these results do not hold once differences in quality are taken into account within the industry. Taking these differences into account, Minondo (2010) develops an index measuring the distance of different nations’ quality of exports from the world quality frontier. His findings suggest that goods with higher potential for quality upgrading, rather than those with high level of productivity, are the ones that lead to faster growth.

To examine the effectiveness of different spillover mechanisms at industry level one set of studies has focused on the spatial spillovers arising from the geographical proximity of firms and institutions, sectoral learning, labour mobility, and the exploitation of patents. The prevalent approach in this field is based on the knowledge-production function which models various measures of regional (national) innovation output such as the number of patents or new products as a function of different forms of spillover, such as cooperation with other firms, universities, or research laboratories (Grilliches, 1979; Jaffe, 1986; Anselin et al., 1997). These studies contend that cooperation with nearby universities and innovating firms from the same industry leads to higher innovation output at the industry level. Another approach has been to examine the relationship between the geographic locations of patent citations and cited patents (Jaffe et al., 1993; Maurseth and Verspagen, 2002). These studies further highlight the importance of localised knowledge spillovers in shaping the ability of industries to compete.

In some studies authors have assumed that knowledge is diffused through labour mobility and interactions between workers in a geographically limited space. In this context spatial spillovers have been measured with employment data, which have been used to construct indices of localisation and urbanisation economies as degrees of industrial specialisation and industrial diversity at a regional level (Baptista and Swan, 1998; Baltzopolous, 2010). The evidence from Baptista and Swan (1998) suggests that the geographical concentration of industries facilitates knowledge sharing and leads to accelerated growth. Baltzopolous
(2010) distinguishes between four types of agglomeration externalities to study the impact of knowledge diffusion on entrepreneurship in high technology-intensive industries: localisation economies, urbanisation economies, spillovers arising from competition, and those based on the level of regional development. The results suggest that localisation economies increase regional entrepreneurial output, while urbanisation economies increase the probability of individuals establishing firms in industries in which they were previously employed.

Besides spatial spillovers, the mechanisms of knowledge diffusion have been looked for in international trade flows. In one set of studies the analysis is limited to spillovers arising from international trade (Hoekman and Djankov, 1997; Dulleck et al., 2005; Monfort et al., 2008; Verhoogen, 2008; Castro Nunez, 2009), while in others the spillovers from international trade are compared with those from domestic trade (Ledesma, 2000; Laursen and Melicians, 2002; Clausen and Pohjola, 2009). A common way to measure international spillovers is to include some form of import measure. To this end, Monfort et al. (2008) have examined how imports from low-cost producers affect the behaviour of incumbent producers in developed countries. Their results demonstrate that the stronger pressure of price-competitive imports motivates incumbent producers to improve the relative sophistication of their goods and to move to the higher quality segment of the market. Studies dealing with developing economies have mainly relied on imports of intermediate inputs as a proxy for inflow of knowledge (Djankov and Hoekman, 1995; Castro Nunez, 2009). The former study shows that stronger intensity of such imports has a positive impact on the trade specialisation of transition economies in sophisticated industries, while the latter reports a similar impact of imports from developed economies on productivity growth in industries in developing economies.

In international trade, knowledge spillovers can also take place through participation in international markets. The ability to compete abroad provides firms with access to up-to-date technology and produces a learning-by-exporting effect. For this reason Dulleck et al. (2004) have modelled international spillovers in new EU member states as an export market share of their industries, while Verhoogen (2008) included export intensity as a mechanism for knowledge diffusion. The former study contends that stronger participation in international markets leads to higher quality of exported products, which is proxied by the relative export unit value. However, it also demonstrates that quality upgrading improves the share of the industry in the international market. The reverse causality between the two variables demonstrates that knowledge spillovers through quality upgrading improve the ability of producers to differentiate
themselves more easily and to seize the market share of their rivals. A similar relationship between export intensity and productivity has been found by Verhoogen (2008).

There have been two ways of comparing domestic and international spillovers. Ledesma (2000) uses two measures representing domestic R&D stock and foreign R&D stock multiplied by the imports/GDP ratio in order to distinguish between the two types of knowledge diffusion mechanisms. Laursen and Meliciani (2002) introduce two measures for domestic spillovers: the ratio between domestic and foreign patents in a given industry, and the share of intermediate inputs from upstream sectors in that industry’s output multiplied by the R&D intensity of the former. Their findings suggest that both patterns of knowledge diffusion can facilitate industries’ international competitiveness, but the impact of domestic knowledge spillovers is stronger than that of the foreign-generated ones. However, Clausen has reported the opposite findings (2009), suggesting that export intensity increases with the intensity of foreign cooperation and declines with increase in domestic cooperation.

Much of the literature on international knowledge spillovers examines the knowledge diffusion effects of foreign direct investment and multinational corporations on innovation activities and the competitiveness of industries (Djankov and Hoekman, 1995; Greeneway et al., 1995; Baldwin et al., 2005; Liu and Shu, 2003; Javorcik, 2004). The stronger presence of multinationals and FDI produces learning externalities, which in turn give rise to innovation activities of domestic firms and consequently growth of their industries. In this context Djankov and Hoekman (1995) have included variables for FDI and for trade under subcontracting arrangements as determinants of industrial specialisation in transition economies, while Greeneway et al. (1995) have examined how stronger concentration of multinational companies within an industry affects the development of intra-industry trade. In other studies authors have used various versions of FDI intensity as controls for technology and knowledge transfer (Baldwin et al., 2005; Liu and Shu, 2003; Javorcik, 2004).

The evidence with respect to the existence of spillovers arising from FDI is ambiguous. Djankov and Hoekman (1995) do not find any impact of FDI on the specialisation of industries in transition economies. Rather, their findings indicate that a far more important factor in the competitiveness of industries in these economies is the subcontracting arrangements. Yet Javorcik (2004) finds evidence of backward spillover linkages affecting the productivity of firms in upstream sectors. Her findings are in line with those of Baldwin et al. (2005)
on the link between FDI and productivity of industries in OECD economies. Greeneway et al. (1995) report that the stronger presence of multinationals in an industry gives rise to horizontal intra-industry trade, while it has a negative impact on vertical intra-industry trade. This finding probably reflects the fact that knowledge spillovers generated through these channels lead to quality upgrading in the industries of lagging economies, which in turn gives rise to trade in products of a similar level of sophistication. This is also confirmed by Liu and Shu (2003), who find that FDI has a positive impact on the export intensity of industries in China.

Summing up the discussion, it is evident that although the empirical literature has analysed the importance of knowledge spillovers for industrial performance and competitiveness, few studies have examined how these spillover mechanisms affect the international competitiveness of industries in terms of their market share. Moreover, in the majority of studies the modelling approach does not take into account the complexity of the mechanism through which knowledge generation and diffusion affect competitiveness. The endogenous growth theory predicts that the causality should go from knowledge spillovers to greater innovation activity of firms within the industry to their improved ability to compete in quality and consequently acquire a higher share of international markets. The model developed in this paper attempts to overcome some of these shortcomings.

4. DATASET

In analysing whether there is any relationship between the innovativeness, quality of products, and market shares of individual industries in the EU market, we employ a dataset of manufacturing industries from several countries which, in the period of analysis (2006), were either members of the EU (Czech Republic, Estonia, Spain, Hungary, Latvia, Lithuania, and the Slovak Republic) or were in the final stage of accession (Bulgaria and Romania), and for which data were made available to us.

The database used in this investigation is obtained by merging three separate data sets. Firstly, the information on firms’ innovative activities has been obtained from the 2006 round of the Community Innovation Survey (CIS 2006). This dataset contains information on innovation activities of all firms with more than
ten employees in all EU member states (as well as a few others). The information provided by individual firms was then aggregated at a 3-digit NACE level to arrive at the innovation activities of 3-digit industries. As the surveys cover all firms with more than ten employees, the aggregation of the firm-level data produces as close a dataset as possible to that of the full industry. The second dataset, containing information on the values and quantities of exports from and imports to the single European market from other EU member states at 3-digit industry level, was extracted from Eurostat’s Comext database. Furthermore, this dataset was combined with the information on production values taken from the Prodcomm dataset in order to construct the market shares of industries from individual countries in the EU27 market. The third dataset, containing information on the structure of 3-digit industries of individual EU member states, such as the number of enterprises, costs of labour, investment in tangible and intangible assets, the number of employees, etc., was extracted from Eurostat’s Structural Business Statistics database. The three datasets obtained in this way were merged together to form a unique industry-level database which has not been used in many previous studies.

Table 1 presents some descriptive statistics related to the competitiveness of exports of industries from EU member states in the single European market in 2006, divided into two groups (the old members, EU15, and those that joined the EU in the two most recent waves of enlargement in 2004 and 2007, the EU10).

1 Access to the raw CIS data for the nine countries in this study was provided at the Eurostat Safe Center in Luxembourg in January 2011, where the empirical work was conducted. The CIS data is available on CD ROM in anonymised form, but it contains fewer variables than the raw dataset at the Safe Center. Not all member states allow access by researchers to the full raw data. Also, for some countries there are high rates of missingness for some parts of the questionnaire, or the variables of interest are missing.
2 This is also a procedure adopted by Eurostat when publishing industry-level information from the CIS data (i.e., the aggregation of firm level data to create information on 2-digit industries).
3 Since the Comext data is classified according to the Combined Nomenclature (CN) classification at the most disaggregated 8-digit level, while other data were organised according to NACE classification, the former dataset had to be first converted and then aggregated to the three-digit level in order to make it comparable with the other two datasets. However, the concordance between NACE and CN classifications is not complete and, therefore, fully comparable data for industrial innovation, trade, and quality could only be created for some 521 observations in the manufacturing industries of the nine countries.
Table 1: EU Market Shares and Unit Export Values of Industries in the EU15 and EU10 in 2006

<table>
<thead>
<tr>
<th>Industry</th>
<th>EU Market share (%)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>UEV</th>
<th>RUEV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EU15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>EU10&lt;sup&gt;c&lt;/sup&gt;</td>
<td>EU15</td>
</tr>
<tr>
<td>Manufacturing industry as a whole</td>
<td>37</td>
<td>4</td>
<td>171</td>
</tr>
<tr>
<td>Low technology-intensive industries</td>
<td>27</td>
<td>3</td>
<td>139</td>
</tr>
<tr>
<td>Medium low technology-intensive industries</td>
<td>33</td>
<td>5</td>
<td>119</td>
</tr>
<tr>
<td>Medium high technology-intensive industries</td>
<td>49</td>
<td>5</td>
<td>184</td>
</tr>
<tr>
<td>High technology-intensive industries</td>
<td>58</td>
<td>8</td>
<td>8877</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based on Comext database

<sup>a</sup> Market share is defined as share of exports from EU 15 or EU10 in apparent consumption

<sup>b</sup> EU15 refers to countries that constituted the European Union prior to the 2004 enlargement

<sup>c</sup> EU10 refer to the Central and East European countries that joined the EU in 2004 and 2007 enlargements

As can be seen from this table, in 2006 the EU market share of exports from EU15 countries to the single European market was over nine times higher than that from the new member states and candidate countries. The division of industries by their technological intensity according to OECD (2007) classification reveals that in all four technological groups the market share of EU15 countries was higher than that of the EU10 (between six and ten times higher). This clearly indicates the low competitiveness of industries from the new member states in the single market.

The ability to compete can be based on prices or on the quality of products. The latter type of competitiveness, as we already argued, enables firms to acquire above-average returns and thus secure higher rates of growth for themselves and their industries and economies. A common indicator of the quality of exported products is their unit value (Fischer, 2007). To this end, it is argued that the country (or the industry) competes in terms of quality if it exports goods of a higher unit value and at same time acquires a higher market share than its rivals.
Table 1 also demonstrates that EU15 countries participate in the single market with goods of higher quality (measured by the unit export values) than their counterparts from new member states. This is true for all types of industries, irrespective of their technological intensity. The difference in unit export values is particularly pronounced in high technology-intensive industries where the unit value of exports to the EU market from the EU15 is about two and a half times that of same goods exported by the EU10. As the theory predicts that innovation plays a crucial role in building quality-based competitiveness, the remaining part of this paper will concentrate on the link between innovativeness, quality of exports, and market share of individual industries in the EU market.

5. MODEL SPECIFICATION

Our modelling strategy is based on propositions from sections 2 and 3 about the mechanisms of knowledge spillover at industry level, which we combine with insights from the literature on the innovation activities of firms. While our primary concern is the relationship between knowledge spillovers, innovation activities, and the international competitiveness of industries, we also include several other variables to control for various factors which may be important for quality upgrading and the ability of industries to compete. Hence our starting point is that knowledge diffusion helps firms to successfully pursue innovation activities and to compete in quality. In line with Schumpeterian reasoning, quality-based competition provides the opportunity for producers to differentiate themselves from rivals. Through quality-driven competitiveness, firms and their industries will be able to seize their rivals’ market share in international markets.

The model developed in this paper estimates the complex interrelation between investment in innovation (innovation input), spillover effects, innovation output, relative quality of exports, and the market share of each country’s industries in the EU27 market, as a system of simultaneous equations. In a simple form, the system is made up of the following three equations:

\[
\begin{align*}
\text{Innovation output} &= f (\text{Innovation input, spillovers, } X^1) \\
\text{Quality of exports} &= f (\text{Innovation output, } X^2) \\
\text{Competitiveness} &= f (\text{Quality of exports, } X^3)
\end{align*}
\]

The first stage of this process is defined in the following equation.
\[ \text{Inout}_{ij} = f(\text{Ininput}_{ij}, \text{Eums}_{ij}, \text{Imp}_{ij}, \text{Size}_{ij}, \text{Uni}_{ij}, \text{Group}_{ij}, \text{VSpill}_{ij}, \text{HSpill}_{ij}, \text{SubDom}_{ij}, \text{SubEU}_{ij}, \text{HCosts}_{ij}, \text{HKnow}_{ij}, \text{OrgIn}_{ij}, \text{MktIn}_{ij}, \text{Tech}_{ij}, \text{Country}_{ij}) \]  

Equation (4) establishes a relationship between the innovation output (\text{Inout}), which is defined as the value of sales arising from products new to the firm and new to the market in industry \( i \) from country \( j \) on the one hand, and knowledge spillovers (shown by several variables discussed below, \text{Eums}, \text{Imp}, \text{Uni}, \text{Group}, \text{VSpill} and \text{HSpill}), investment in innovation activities, and a set of other control variables on the other hand. This variable is constructed on the basis of responses of firms in the CIS 2006 dataset aggregated at the 3-digit NACE level. The same dataset is the source of data on investment in innovation or innovation input (\text{Ininput}), which is defined as the total innovation expenditure of industry \( i \) in country \( j \) divided by the mean value of this variable in the individual country. Numerous findings from firm-level studies, particularly those from the multi-stage CDM-type models, suggest that there is a positive relationship between investment in innovation and innovation output that remains robust to how the two variables are measured. For this reason we expect to find a positive sign in this variable at industry level too.

To account for knowledge spillovers we include several proxies to approximate different types of spillover, as the calculation of the precise level of spillovers is not possible with the CIS data. The knowledge arising as a side product of the firms’ (and their industries’) involvement in international trade is captured by two variables (the learning-by-exporting effect and the competitive pressure from imports, especially high quality imports). First, to control for the learning-by-exporting effect, the EU market share of each industry (\text{Eums}) is included. We expect the firms’ operation in the EU market to increase the probability of their access to the knowledge of new products and processes. The competitive pressure in the EU market is also expected to serve as an incentive for firms to engage more intensively in innovation activities. Of course, it is also possible that producers with a higher market share adopt a ‘quiet life’ policy and thus have a weaker incentive to innovate. The overall effect of this variable, therefore, is not known a priori.

The second variable capturing knowledge spillovers from international trade is the relative quality of the industry’s imports (\text{Imp}), defined as the ratio of the unit value of imports in that industry from other EU27 members to the mean unit value of intra-EU27 imports (i.e., the quality of imports of a specific industry relative to the average quality of imports within the EU). On the one hand, we
expect that pressure from high quality imports acts as an incentive for firms to engage actively in innovation activities in order to differentiate themselves from foreign rivals. Similarly, the quality-competitive imports may induce spillovers to local firms through competition and cooperation. Yet it is also possible that the stronger presence of imports may act as an impediment to the innovation activities of firms by stealing their market and thus reducing funds available for restructuring and quality upgrading of their production. Therefore, for this variable too, there is no a priori expectation about its sign.

While we are unable to control directly for spatial spillovers due to lack of data on the location of firms in the CIS survey, several variables are included which can be considered as close measures of agglomeration externalities. The first is defined as the proportion of firms in each industry that consider cooperation with universities (\(Uni\)) as a highly important source of information for innovation. This ratio is expected to represent the general knowledge spillovers from cooperation with scientific institutions. The second measure aims to capture the horizontal intra-industry spillovers arising from the actions of other rivals (\(HSpill\)). Analogous to the previous measure, it is defined as the proportion of firms in each industry that consider the actions of rivals as highly important sources of information for innovation. The third measure indicates the relative importance of vertical spillovers to the innovation activities of firms (\(VSpill\)), which is defined as the proportion of firms in each industry that consider suppliers and customers as important sources of information for innovation. The last spillover measure is the benefit derived by firms for being members of a group (\(Group\)); often this may be a multinational firm where the benefits to members of the group are well established. It is defined as the proportion of firms in an industry that are part of a group. All these variables are expected to have positive signs.

In addition to investment in innovation and knowledge spillovers the model includes several other control variables. The relative size of industry (\(Size\)) is defined as the number of employees in that industry divided by the average number of employees in that industry at the EU27 level. Larger industries are likely to be characterised by greater economies of scale and therefore their firms would be more inclined to innovate. However, it is also possible that the larger size of an industry leads to the previously described ‘quiet life’, as firms might be less interested in innovation and might instead focus on harvesting the fruits of their previous activities. Therefore we do not have an expected sign for this variable.
Two variables are included to control for the access of firms to subsidies from domestic (SubDom) and EU (SubEU) sources. These variables are defined as the ratio of the number of firms in each industry that receive one of these subsidies to the total number of firms in that industry. Access to subsidies may complement the firms’ efforts in transforming investment in innovation into innovation output. On the other hand, in the absence of strict controls over the use of these subsidies, they can also be used to finance other kinds of activity. Moreover, the long-term access to subsidies may create a culture of dependency, which may make the firms complacent and weaken their desire to engage in innovation activities. Hence, the effect of this variable is ambiguous.

The model also controls for factors hampering innovation activities with two variables. The CIS questionnaire asks the respondents to rank various barriers to their innovation activities (in particular, cost factors and knowledge factors). The cost barriers to innovation enter the model through the variable (HCosts), defined as the proportion of firms in each industry that consider costs as a ‘highly important’ barrier to innovation. Similarly, knowledge barriers to innovation are proxied by the variable (HKnow), defined as the proportion of firms in each industry that consider knowledge factors as a ‘highly important’ barrier to innovation. For both variables we expect a negative sign.

To control for the factors facilitating innovation throughput (transformation of innovation inputs into innovation output) we include two variables representing organisational innovation (OrgIn) and marketing innovation (MktIn). Similarly to previous variables, these are also constructed as the proportion of firms in each industry that introduced organisational and marketing innovations. Organisational innovations may be seen as channels for improvements in the efficiency of firms, thus facilitating transformation of innovation inputs to outputs. Marketing innovation may be a valuable source of differentiation, particularly in the Central and East European countries. Chisik (2003) demonstrates that the ability of producers to compete in quality may be constrained if they come from countries which are perceived as producers of low-quality goods. Bearing in mind that the competitiveness profiles of new EU member states have for a long time been driven by price competitiveness, we consider marketing innovations to be particularly important in these countries. For both variables we expect positive signs. Finally, we include three control variables for the technological intensity of industries based on the OECD Classification (Techij) and for the country of origin (Country).
The second stage of the model analyses the relationship between the innovation activities of the industry and the relative quality of its exports. The model takes the following form:

\[ R_{euvij} = f(Inout_{ij}, Size_{ij}, Imp_{ij}, ExpNo_{ij}, W_{premium_{ij}}, InvEmpl_{ij}, Group_{ij}, Tech_{ij}, Country_{ij}) \]  

(5)

In equation (5) the dependent variable is the relative unit export value \((R_{euv})\), defined as the ratio of the unit value of exports to the EU27 from industry \(i\) in country \(j\) to the unit export value of that industry in the EU 27. In addition to the innovation output from the previous stage and the several variables defined earlier, in this stage of the model we include the proportion of firms in each industry who declare themselves to be exporters, as a measure of international trade spillovers \((ExpNo)\). Furthermore, the skill intensity of each industry is measured by the ratio of the average wage paid in the industry and the average wage paid in that industry at the EU27 level \((W_{premium})\). We expect that higher wages in an industry reflect efforts of firms to attract skilled workers who can contribute to the quality upgrading of their exports. For this reason we expect a positive sign in this variable. Equation (5) also includes the ratio of investment in machinery and equipment in each industry to the number of employees in that industry. We expect that, in general, higher investment in new technology and higher capital intensity of an industry will have a positive impact on the quality of its exports.

In the third stage of the model we examine the relationship between the relative quality of exports from industry \(i\) to the single European market in each country and the market share of that industry in the EU market. As previously mentioned, we expect that the higher quality of goods will result in an increased market share of that industry. For this reason the third and final stage of our model is defined as:

\[ E_{ums_{ij}} = f(R_{euv_{ij}}, Size_{ij}, Prod_{ij}, InvEmpl_{ij}, Group_{ij}, ExpNo_{ij}, Tech_{ij}, Country_{ij}) \]  

(6)

The dependent variable in equation (6) is market share of industry \(i\) from country \(j\) in the single European market. It is specified as a function of the relative unit export values \((R_{euv})\) from the previous stage and several control variables. In addition to the previously defined variables, here we include labour productivity

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4 Unit export value is calculated as the value of exports divided by the weight of exports (€ per physical unit).
of the industry (Prod). It is often argued that the ability of firms, industries, and nations to compete rests on their labour productivity, which in this context can be interpreted as a sign of efficiency (Porter, 1998). For this reason we expect to find a positive sign in this variable.

6. DISCUSSION OF FINDINGS

The model developed in this paper rests on the assumption that causality runs from the innovation activities of industries, to the quality of their exports, to their market shares. These three stages are likely to be determined by some common set of observed and unobserved factors, which gives rise to the potential problem of endogeneity. Furthermore, the dependent variable from the third stage enters the right hand side of the first stage equation (also the dependent variable of the first stage enters the second stage equation). In order to control for this feature of the model we employ a simultaneous equation framework, the Three Stage Least Squares technique (3SLS), which, in addition to controlling for the potential endogeneity of some of the variables, allows for the feedback effect from the EU market share to the firms’ innovation activities. In this setting the endogenous variables are instrumented with instruments found within the system (other explanatory variables). The results of the estimation of the three stages are presented in Table 2.

All continuous (non-categorical) variables are in logarithmic form. One of most studied issues in the innovation literature is the relationship between innovation input (investment in R&D) and different measures of innovation output. The second column of Table 2 shows that, in line with much of the literature on innovation, there is a statistically significant and positive relationship between innovation input and innovation output. A 1% increase in investment in innovation activities leads to an increase in turnover from new products of about 0.72%.
Table 2. Results of estimations

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Innovation output equation (1st stage)</th>
<th>Relative unit export value equation (2nd stage)</th>
<th>EU market share equation (3rd stage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eums</td>
<td>1.97 (0.001)**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Imp</td>
<td>-0.19 (0.074)*</td>
<td>0.13 (0.000)**</td>
<td>-</td>
</tr>
<tr>
<td>Ininput</td>
<td>0.72 (0.000)**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Inoutput</td>
<td>-</td>
<td>0.04 (0.025)**</td>
<td>-</td>
</tr>
<tr>
<td>Reuv</td>
<td>-</td>
<td>-</td>
<td>0.44 (0.041)**</td>
</tr>
<tr>
<td>Size</td>
<td>-0.50 (0.194)</td>
<td>-0.08 (0.297)</td>
<td>0.56 (0.000)**</td>
</tr>
<tr>
<td>Uni</td>
<td>-4.88 (0.342)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Group</td>
<td>-6.69 (0.048)**</td>
<td>-1.10 (0.126)</td>
<td>1.46 (0.165)</td>
</tr>
<tr>
<td>VSpill</td>
<td>8.30 (0.027)**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HSpill</td>
<td>8.28 (0.097)**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SubDom</td>
<td>-10.81 (0.093)*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SubEU</td>
<td>19.64 (0.059)*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HCosts</td>
<td>-0.12 (0.977)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HKnow</td>
<td>-4.06 (0.320)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>OrgIn</td>
<td>-3.88 (0.637)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MktIn</td>
<td>10.06 (0.430)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ExpNo</td>
<td>-</td>
<td>-0.001 (0.323)</td>
<td>0.002 (0.200)</td>
</tr>
<tr>
<td>Wpremium</td>
<td>-</td>
<td>0.41 (0.141)</td>
<td>-</td>
</tr>
<tr>
<td>Invempl</td>
<td>-</td>
<td>0.13 (0.049)**</td>
<td>-0.09 (0.232)</td>
</tr>
<tr>
<td>Prod</td>
<td>-</td>
<td>-</td>
<td>0.20 (0.004)**</td>
</tr>
</tbody>
</table>

Observations: 503 503 503

Source: Author's calculations

p-values in brackets; ***, ** and * denote conventional significance of coefficients at 1%, 5% and 10% respectively; all equations include dummy variables for country and for technological intensity of industries.

The coefficients for knowledge spillovers arising from international trade are statistically significant but with different signs. A 1% increase in EU market share of an industry increases innovation output in that industry by about 2%. However, the coefficient on import intensity, the second variable controlling for spillovers from imports, is negative and significant, suggesting that an increase in the quality of imports in the domestic market by 1% reduces the innovation output of the industry by about 0.2%. In interpreting these findings we must take into account the fact that the bulk of our sample are industries from the new
EU member states of Central and Eastern Europe, where the knowledge gained through competition in the markets of other EU countries provides their firms with new knowledge of products and production processes which can be applied at home in the development of their own innovations.

Other variables measuring spillovers are all significant, with the exception of the variable representing cooperation with universities and research institutions, which is insignificant. However, the signs of these variables differ. On the one hand, the coefficient of the variable representing intra-group knowledge spillovers has a negative sign, suggesting that a 1% increase in the number of firms that are part of a group reduces turnover of industry from new products by about 6.6%. On the other hand, channels of vertical and horizontal spillovers such as cooperation with suppliers and customers or with competitors have positive impacts on the innovativeness of an industry. While the latter two findings are consistent with theoretical expectations, the former finding is somewhat puzzling. A likely explanation is that membership of a group implies that investment in R&D and innovative activities takes place in the country of origin of the mother firm (probably in more advanced countries) and reduces the need for group members (especially in new member states) to engage in innovative activities.

Among other control variables, the two variables representing access to subsidies are significant. The coefficient of the variable indicating the use of domestic subsidies is negative, while the one on access to EU subsidies is positive. This finding probably reflects the fact that rules governing the use of domestic subsidies are less strict than those governing subsidies at the EU level. Finally, the variables representing barriers to innovation and those representing the involvement of firms in organisational and marketing innovations are statistically insignificant.

The results of the second stage are mainly consistent with our expectations. The existence of causality running from firms’ innovation activities to the quality of exports from their industries in the EU27 market can be confirmed. A 1% increase in the innovation output of an industry increases the relative quality of its exports by about 0.04%. Similarly, the better quality of imports has a positive impact on the relative quality of the industry’s exports. On the one hand, this can be evidence of spillovers generated through international trade. On the other hand, such finding may be a consequence of intra-industry trade and outsourcing of production from other EU members to countries in our sample. In such a setting transfer pricing could be used as the mechanism to increase the relative unit export values of goods exported by industries in the sample, which can be easily interpreted as an indicator of improvements in quality. However, the
limitations of our dataset prevent us from further investigation of these issues. Finally, the results also show a positive and statistically significant coefficient for investment in machinery and equipment. A 1% increase in investment per employee increases the relative quality of the industry’s exports by about 0.13%.

As the last part of the investigation we examine the relationship between the relative quality of exports and the market share of an industry in the EU market. As the discussion in section 4 highlighted, industries with the highest share of the EU market are also those with the highest relative unit export values. Table 2 shows that there is a positive and statistically significant relationship between the two. A 1% increase in the relative quality of exports increases the EU market share of an industry by about 0.44%. We also obtain a positive and statistically significant sign on the coefficient of the industry size. An increase in the relative size of the industry by 1% increases its market share by about 0.56%. It is therefore likely that the mechanisms of spillovers generated through competition, such as those mentioned earlier in this paper, are at work. Finally, the market share of an industry in the EU market is positively influenced by the productivity of labour in that industry. Such a finding can be taken as evidence that improvements in efficiency play an important role in building the competitiveness of industries in the single market.

7. CONCLUSIONS

Over the past decades politicians, policy makers, and businessmen in EU member states have on many occasions emphasised as their overriding long-run objective the building of knowledge- and technology-intensive economies, capable of generating high growth rates by improving competitiveness in the quality segment of international markets. With the recent enlargement the competitive profiles of EU countries have become more heterogeneous than ever. While mature Western European member states have demonstrated signs of movement towards knowledge, technology, and quality-driven competitiveness, the competitive profiles of producers in the new member states of Central and Eastern Europe have remained mainly dominated by price-driven competition.

In recent years the trade and growth literature has devoted much attention to the relationship between the structure of a nation’s exports and its growth prospects. Traditionally, this line of research has argued that the ability of nations to export increases their growth prospects. More recent contributions have underlined the fact that the structure of a country’s exported products is far more important
for understanding the differences in growth of today’s economies. It is generally agreed that competitiveness based on knowledge- and technology-intensive products offers a better prospect for growth than the production of labour- and resource-intensive goods, which bear little added value and can be more easily imitated. This has resulted in the development of new theories that attempt to establish how the quality of nations’ exports can be improved, and thus how the policy makers can develop policies aimed at improving the ability of firms and industries to compete in terms of quality.

Quality-driven competitiveness, of course, is closely related to the innovation activities of firms and industries. The introduction of new goods and services and the development of new ways of doing things enable firms to differentiate themselves from their rivals and to enjoy temporary monopoly power, thus capturing above average returns. However, the benefits of such behaviour are not reserved for practising firms, as newly discovered knowledge gets diffused across the market through various spillover channels such as trade, competition, interactions within a group of firms, and interactions with suppliers and distributors. To this end the identification of these channels and understanding of their relative importance for firms in individual countries or in groups of countries can help policymakers in adopting measures that facilitate the development of quality-driven competitiveness among their firms and industries.

The results of our investigation confirm the existence of a relationship between the innovation activities of industries, the quality of their exports, and their competitiveness measured by their EU market share. In this process an important role is played by knowledge spillovers, particularly those generated through international trade, horizontal and vertical interactions in the domestic market, and within-group exchange of knowledge. Furthermore, empirical evidence establishes that public support, in the form of EU-based subsidies, is far more important for the success of innovation activities among firms than domestic subsidies. Our results also point to substantial discrepancies in the representation of industries from new and old EU member states in the EU market and in the quality of their exports. Our findings about factors and forces that facilitate innovation behaviour, quality upgrading, and competitiveness of EU industries in general, may be taken as a basis for the development of future policies aimed at reducing these discrepancies.
REFERENCES


## APPENDIX

### Table A1. Description of variables

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inout</strong></td>
<td>Innovation output - Value of sales arising from products new to the firm and new to the market in each industry and country (in log form)</td>
</tr>
<tr>
<td><strong>Eums</strong></td>
<td>EU market share – Exports of each industry to the EU27 divided by EU27 apparent consumption (total output plus imports minus exports of the industry – in log form)</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>Relative Size of the industry - Number of employees in industry $i$ in country $j$ divided by the average number of employees in that industry in the EU27 (in log form)</td>
</tr>
<tr>
<td><strong>Imp</strong></td>
<td>Relative quality of imports – Unit value of imports from other EU27 members divided by average unit value of intra-EU27 imports (in log form)</td>
</tr>
<tr>
<td><strong>Ininput</strong></td>
<td>Innovation input (investment in innovation) – Total innovation expenditure of industry $i$ from country $j$ divided by the mean value of innovation input in country $j$ (in log form)</td>
</tr>
<tr>
<td><strong>Uni</strong></td>
<td>Cooperation with universities – Number of firms in each industry and country that consider cooperation with universities as a highly important source of information for innovations divided by total number of firms in that industry and country (in log form)</td>
</tr>
<tr>
<td><strong>Group</strong></td>
<td>Intra-group spillovers – number of firms in an industry which are part of a group divided by total number of firms in that industry (in log form)</td>
</tr>
<tr>
<td><strong>VSpill</strong></td>
<td>Vertical spillovers – Number of firms in each industry that consider suppliers and customers as important sources of information for innovations divided by total number of firms in that industry (in log form)</td>
</tr>
<tr>
<td><strong>HSpill</strong></td>
<td>Horizontal spillovers – Number of firms in each industry that consider rivals as important sources of information for innovations divided by total number of firms in that industry (in log form)</td>
</tr>
<tr>
<td><strong>SubDom</strong></td>
<td>Access to domestic subsidies – Number of firms in each industry that receive domestic subsidies divided by total number of firms in that industry (in log form)</td>
</tr>
</tbody>
</table>
Access to EU subsidies – Number of firms in each industry that receive EU subsidies divided by total number of firms in that industry (in log form)

Cost barriers to innovation – Number of firms in each industry that consider costs as a highly important barrier to innovation divided by total number of firms in that industry (in log form)

Knowledge barriers to innovation – Number of firms in each industry that consider the shortage of relevant knowledge as a highly important barrier to innovation divided by total number of firms in that industry (in log form)

Organisational innovations – Number of firms in each industry that introduced organisational innovation divided by total number of firms in that industry (in log form)

Marketing innovations - Number of firms in each industry that introduced marketing innovation divided by total number of firms in that industry (in log form)

Relative unit export value – Unit value of exports to the EU27 from each industry $i$ from country $j$ divided by unit export value in EU27 (in log form)

Wage premium (or skill premium) – Average wage per employee paid in each industry and country divided by average wage paid in that industry at EU27 level (in log form)

Investment per employee (capital intensity) – Investment in machinery and equipment divided by number of employees in each industry (in log form)

Labour productivity – Turnover divided by number of employees in each industry

Technology Dummy 1, equals 1 if industry is classified as medium low technology-intensive

Technology Dummy 2, equals 1 if industry is classified as medium high technology-intensive

Technology Dummy 3, equals 1 if industry is classified as high technology-intensive

Country Dummies (8)

Source: Authors

Received: September 02, 2013
Accepted: October 18, 2013